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NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

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in its capacity as elected Office

Date of mailing (day/month/year) 10 May 1999 (10.05.99)	
International application No. PCT/US98/18938	Applicant's or agent's file reference
International filing date (day/month/year) 11 September 1998 (11.09.98)	Priority date (day/month/year) 11 September 1997 (11.09.97)
Applicant DEARNALEY, Geoffrey et al	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:

09 April 1999 (09.04.99)

☐ in a notice effecting later election filed with the International Bureau on:2. The election ☒ was☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer Lazar Joseph Panakal Telephone No.: (41-22) 338.83.38
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PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)


REC'D 15 FEB 2000

WIPO PCT

Applicant's or agent's file reference SWRI-2385Y		FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/US98/18938	International filing date (day/month/year) 11 SEPTEMBER 1998	Priority date (day/month/year) 11 SEPTEMBER 1997	
International Patent Classification (IPC) or national classification and IPC IPC(6): C23C 16/26; H01M 8/10; B05D 5/12 and US Cl.: 427/115,250,294; 204/294; 429/44			
Applicant SOUTHWEST RESEARCH INSTITUTE			

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 4 sheets.
☒ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).
 These annexes consist of a total of 17 sheets.

3. This report contains indications relating to the following items:
 - I ☒ Basis of the report
 - II ☐ Priority
 - III ☐ Non-establishment of report with regard to novelty, inventive step or industrial applicability
 - IV ☐ Lack of unity of invention
 - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
 - VI ☐ Certain documents cited
 - VII ☐ Certain defects in the international application
 - VIII ☐ Certain observations on the international application

Date of submission of the demand 09 APRIL 1999	Date of completion of this report 27 OCTOBER 1999
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer  BRIAN TALBOT
Facsimile No. (703) 305-3230	Telephone No. (703) 308-0661

I. Basis of the report

1. This report has been drawn on the basis of *(Substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments)*:

- ☐ the international application as originally filed.
- ☒ the description, pages 1-26 , as originally filed.
pages NONE , filed with the demand.
pages NONE , filed with the letter of _____
pages _____ , filed with the letter of _____
- ☒ the claims, Nos. NONE , as originally filed.
Nos. NONE , as amended under Article 19.
Nos. 1-47 , filed with the demand.
Nos. NONE , filed with the letter of _____
Nos. _____ , filed with the letter of _____
- ☒ the drawings, sheets/fig NONE , as originally filed.
sheets/fig 1-16 , filed with the demand.
sheets/fig NONE , filed with the letter of _____
sheets/fig _____ , filed with the letter of _____

2. The amendments have resulted in the cancellation of:

- ☒ the description, pages NONE .
- ☒ the claims, Nos. NONE .
- ☒ the drawings, sheets/fig NONE .

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the ~~Supplemental Box~~ Additional observations below (Rule 70.2(c)).

4. Additional observations, if necessary:

NONE

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**1. STATEMENT**

Novelty (N)

Claims	<u>1-47</u>	YES
Claims	<u>NONE</u>	NO

Inventive Step (IS)

Claims	<u>NONE</u>	YES
Claims	<u>1-47</u>	NO

Industrial Applicability (IA)

Claims	<u>1-47</u>	YES
Claims	<u>NONE</u>	NO

2. CITATIONS AND EXPLANATIONS

Claims 1-44 lack an inventive step under PCT Article 33(3) as being obvious over Tou et al. (5,518,831) in view of Reddy et al. (5,084,144).

Tou et al. (5,518,831) teaches an electrocatalytic structure. Tou et al. (5,518,831) teaches applying a catalyst material by vacuum deposition onto the substrate, i.e. sputtered or evaporation (col. 3, lines 1-40). The electrocatalytic structure can be utilized in a fuel cell. The substrate is carbon fiber paper (col. 3, lines 55-65). The deposition technique can be performed a number of times to achieve the desired thickness and catalyst loading (col. 4, lines 35-45). The electrocatalyst can comprise any metal such as platinum, silver, etc. (col. 9, lines 30-40). Looking at the Examples the catalyst loading per layer can be 0.01 mg/cm². Any number of layer can be applied in order to reach a catalyst loading of up to 0.5 mg/cm² for a 50 layer.

Tou et al. (5,518,831) fails to teach that the catalyst coating consists essentially of the catalytic components.

Reddy et al. (5,084,144) teaches that it is well known in the art to sputter a catalyst layer of platinum onto a NAFION-impregnated electrode for making fuel cells (col. 3, lines 5-17).

Therefore, it would have been obvious at the time the invention was made to have modified Tou et al. (5,518,831) matrix-structured catalyst by forming a catalyst layer comprising only the catalyst component as evidenced by Reddy et al. (5,084,144) because of the expectation of achieving similar success.

Claims 44-47 lack an inventive step under PCT 33(3) as being obvious over either Tou et al. (5,518,831) in view of Reddy et al. (5,084,144) alone or in combination further in view of Kujas (4,460,660).

Tou et al. (5,518,831) in view of Reddy et al. (5,084,144) fail to teach a coating on the carbon substrate.

Kujas (4,460,660) teaches a negative hydrogen electrode comprising an alloy palladium and ruthenium on a suitable support (Continued on Supplemental Sheet.)

Supplemental Box

(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Boxes I - VIII

Sheet 10

V. 2. REASONED STATEMENTS - CITATIONS AND EXPLANATIONS (Continued):

material (see abstract). This catalytic electrode can be used in the manufacturing of fuel cells such as a nickel-hydrogen cell (col. 1, lines 5-15). A dispersion of polytetrafluoroethylene (PTFE) is admixed with a dispersion of activated carbon and pressed into a nickel support. Subsequently, the (combination) is baked at 135 degrees Celsius for two hours to remove the water. The baked porous carbon is used as the support for a catalytic electrode. The support structure is provided with the subject catalyst materials by one of two methods. In the first, the palladium and ruthenium, as their chlorides are dissolved in sufficient isopropyl alcohol to produce a solution. The support material is immersed in the solution for about five minutes, drained and dried in an oven at about 85 degrees Celsius for about four hours. It is preferred to immerse under vacuum and then the structure is heated in a hydrogen atmosphere to about 800 degrees Celsius to reduce the salts to the free metals and form the impregnated palladium-ruthenium alloy (col. 1, line 27 - col. 2, line 5). Kujas (4,460,660) teaches that it is known in the art to use other catalysts such as platinum, niobium and the like (col. 1, lines 50-55). Kujas (4,460,660) teaches a ration of catalyst varying up to 55%/45% (col. 3, lines 50-57).

Therefore, it would have been obvious for one skilled in the art at the time the invention was made to have substituted Kujas's (4,460,660) carbon coated substrate (coated with TEFLON) for Tou et al. (5,518,831) carbon substrate because one skilled in the art would have had a reasonable expectation of achieving similar success regardless of whether the substrate was strictly carbon or carbon coated with a wet-proofing material.

Applicant argued that the prior art fails to teach a coating "consisting essentially of" one or more catalytic components, etc.

Reddy et al. (5,084,144) teaches that it is well known in the art to sputter catalyst on a support for fuel cells. The catalyst consists of only platinum. In addition, while the Examiner acknowledges the fact that Kujas (4,460,660) deposits the catalyst in solution v. vapor deposition, i.e. sputtering, it is noted that Kujas's (4,460,660) catalyst is also comprised of only the catalyst material, i.e. ruthenium and palladium. This supports the showing that "pure" catalysts are well known in the art regardless of how they are deposited.

Applicant argued that the prior art teaches coating by sputtering which does not convert the catalytic component into a vapor as opposed to PVD, i.e. electron beam.

The Examiner disagrees. The claims as written are not limited to EB-PVD as argued by applicant. The claims merely recite forming a vapor which is met by the prior art's sputtering process.

Claims 1-47 meet criteria for PCT Article 33(2) and 33(4) because the claims are novel and industrially applicable as directed toward the field of endeavor in light of the prior art found.

NEW CITATIONS

US 5,084,144 A (REDDY ET AL.) 28 JANUARY 1992, COL. 3, LINES 5-17.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

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We claim:

1 1. A method for depositing onto a support a vaporizable composition
2 comprising a catalytic component, said method comprising:
3 converting said vaporizable composition into a vapor; and
4 depositing said vapor onto said support in an amount sufficient to produce a
5 concentration of said catalytic component adapted to produce a
6 catalytically effective coating on said support.

1 2. The method of claim 1 wherein at least said depositing occurs in a
2 vacuum.

1 3. The method of claim 1 or 2 wherein said support is a carbon catalyst
2 support.

1 4. The method of claim 3 wherein said carbon catalyst support comprises a
2 material selected from the group consisting of graphite, a carbon filament bundle,
3 reticulated carbon, carbon cloth, and carbon mesh.

Replaced by Art 19

1 5. The method of any of claims 1-4 wherein said support comprises a
2 membrane comprising a composite of polytetrafluoroethylene comprising impregnated
3 ion exchange media, said composite comprising a thickness of about 1 μm .

1 6. The method of any of claims 1-5 wherein said vaporizable composition
2 comprises a noble metal.

1 7. The method of any of claims 1-6 wherein said catalytic component
2 comprises a metal selected from the group consisting of platinum, gold, silver,
3 palladium, ruthenium, rhodium, and iridium.

1 8. The method of any of claims 1-7 wherein said concentration comprises less
2 than about 0.3 mg/cm^2 .

1 9. The method of any of claims 1-7 wherein said concentration comprises less
2 than about 0.2 mg/cm^2 .

1 10. The method of any of claims 1-7 wherein said concentration comprises

2 from about 0.01 to about 0.2 mg/cm².

1 11. The method of any of claims 1-10 wherein said catalytic component
2 comprises platinum.

1 12. The method of any of claims 1-11 wherein said support is a coating on a
2 carbon cloth, wherein said coating is selected from the group consisting of carbon, a
3 wet proofing material, and a combination thereof.

1 13. The method of claim 12 wherein said wet proofing material is polytetra-
2 fluoroethylene.

1 14. The method of any of claims 1-13 further comprising
2 providing a solid polymer electrolyte membrane; and
3 disposing said support in ionic communication with said solid polymer
4 electrolyte membrane.

1 15. The method of any of claims 1-14 wherein
2 said solid polymer electrolyte membrane has a first side and a second side
3 opposite said first side, and
4 said method further comprises disposing said support on each of said first side
5 and said second side to produce a membrane electrode assembly.

1 16. An electrode produced by a process comprising:
2 converting a vaporizable composition comprising a catalytic component into a
3 vapor; and
4 depositing said vapor onto a support in an amount sufficient to produce a
5 concentration of said catalytic component adapted to produce a
6 catalytically effective coating on said support.

1 17. The electrode of claim 16 wherein said support is a carbon catalyst support
2 comprising a material selected from the group consisting of graphite, a carbon filament
3 bundle, reticulated carbon, carbon cloth, and carbon mesh.

1 18. The electrode of claim 17 wherein said carbon catalyst support

2 comprises a material selected from the group consisting of a carbon cloth and a coating
3 on a carbon cloth selected from the group consisting of carbon, a wet proofing
4 material, and a combination thereof.

1 19. The electrode of claims 16-18 wherein said support comprises a
2 membrane comprising a composite of polytetrafluoroethylene comprising impregnated
3 ion exchange media, said composite comprising a thickness of about 1 μm .

1 20. The electrode of any of claims 16-19 wherein said vaporizable composition
2 comprises a noble metal.

1 21. The electrode of claim 20 wherein said catalytic component comprises a
2 metal selected from the group consisting of platinum, gold, silver, palladium,
3 ruthenium, rhodium, and iridium.

1 22. The electrode of any of claims 16-21 wherein said catalytic component
2 comprises platinum.

1 23. The electrode of any of claims 16-22 wherein said support comprises a
2 coating on a carbon cloth wherein said coating is selected from the group consisting of
3 carbon, a wet proofing material, and a combination thereof.

1 24. The electrode of claim 23 wherein said wet proofing material is
2 polytetra-fluoroethylene.

1 25. An electrode comprising a support comprising a vacuum deposited
2 electrocatalyst disposed thereon, wherein said electrocatalyst is present in an amount
3 of about 0.3 mg/cm² or less.

1 26. The electrode of claim 25 wherein said electrocatalyst is deposited in a
2 vacuum by ion beam assisted deposition.

1 27. The electrode of claims 25 and 26 wherein, at a cell potential of about 0.6
2 V, an MEA containing said electrode half cell operating as a cathode yields about 800
3 mA cm⁻² or greater.

1 28. The electrode of claims 25-27 wherein said electrode comprises an
2 electrocatalytic active area of about 300 cm² or greater.

1 29. The electrode of claims 25-28 wherein said catalyst comprises platinum.

1 30. The electrode of claims 25-39 wherein said support comprises a
2 membrane comprising a composite of polytetrafluoroethylene comprising impregnated
3 ion exchange media, said composite comprising a thickness of about 1 μm.

1 31. An electrode comprising a support comprising a deposit disposed
2 thereon, said deposit comprising a catalytically effective load of an electrocatalyst
3 comprising an electrocatalytic active area at least in part comprising rod-shaped
4 structures.

1 32. The electrode of claim 31 wherein said rod-like structures are visible at
2 a magnification of at least about x10k.

1 33. The electrode of claims 31 and 32 wherein said deposit further

2 comprises particles of said electrocatalyst comprising an outer surface, wherein said
3 electrocatalytic active area comprises a majority of said outer surface of said particles.

1 34. The electrode of claims 31-33 wherein said support has a surface area, and
2 said deposit covers about 300 cm² or more of said surface area.

1 35. The electrode of claims 31-34 wherein said catalyst comprises platinum.

1 36. The electrode of claims 31-35 wherein, at a cell potential of about 0.6
2 V, an MEA containing said electrode as a half cell operating as a cathode yields a
3 power output of about 400 mA cm⁻² or greater.

1 37. The electrode of claims 31-36 wherein, at a cell potential of about 0.6
2 V, an MEA containing said electrode as a half cell operating as a cathode yields a
3 power output of about 800 mA cm⁻² or greater.

1 38. The electrode of claims 31-47 wherein, at a cell potential of about 0.6
2 V, an MEA containing said electrode as a half cell operating as a cathode yields a

3 power output of about 1000 mA cm⁻² or greater.

1 39. The electrode of claims 31-38 wherein said support comprises a
2 membrane comprising a composite of polytetrafluoroethylene comprising impregnated
3 ion exchange media, said composite comprising a thickness of about 1 μm.

1 40. A membrane electrode assembly comprising the support of any of claims
2 15-39.

1 41. The electrode of any of claims 15-39 wherein
2 said support has a surface area; and,
3 substantially all of said surface area ionically communicates with an ionomeric
4 membrane.

1 42. The electrode of claim 42 wherein said surface area is 300 cm² or
2 greater.

AMENDED CLAIMS

[received by the International Bureau on 27 January 1999 (27.01.99);
original claims 1-42 replaced by new claims 1-47 (10 pages)]

- 1 1. A method for depositing onto a support one or more catalytic components,
2 said method comprising:

3 providing one or more vaporizable catalytic components;

4 converting said one or more vaporizable catalytic components into a vapor, and
5 depositing said vapor onto said support in an amount sufficient to produce a
6 concentration of said one or more catalytic components adapted to
7 produce a catalytically effective coating consisting essentially of said
8 one or more catalytic components on said support.

- 1 2. The method of claim 1 wherein at least said depositing occurs in a
2 vacuum.

- 1 3. The method of claim 1 or 2 wherein said support is a carbon catalyst
2 support.

- 1 4. The method of claim 3 wherein said carbon catalyst support comprises a
2 material selected from the group consisting of graphite, a carbon filament bundle,

REPLACE by Art 34

3 reticulated carbon, carbon cloth, and carbon mesh.

1 5. The method of any of claims 1-4 wherein said support comprises a
2 membrane comprising a composite of polytetrafluoroethylene comprising impregnated
3 ion exchange media, said composite comprising a thickness of about 1 μm .

1 6. The method of any of claims 1-5 wherein said one or more catalytic
2 components comprises one or more noble metals.

1 7. The method of any of claims 1-6 wherein said one or more catalytic
2 components comprises one or more metals selected from the group consisting of
3 platinum, gold, silver, palladium, ruthenium, rhodium, iridium.

1 8. The method of any of claims 1-7 wherein said concentration comprises less
2 than about 0.3 mg/cm^2 .

1 9. The method of any of claims 1-7 wherein said concentration comprises less
2 than about 0.2 mg/cm^2 .

1 10. The method of any of claims 1-7 wherein said concentration comprises
2 from about 0.01 to about 0.2 mg/cm².

1 11. The method of any of claims 1-10 wherein said one or more catalytic
2 components comprise platinum.

1 12. The method of any of claims 1-11 wherein said support is a coating on a
2 carbon cloth, wherein said coating is selected from the group consisting of carbon, a
3 wet proofing material, and a combination thereof.

1 13 The method of claim 12 wherein said wet proofing material is polytetra-
2 fluoroethylene.

1 14. The method of any of claims 1-13 further comprising
2 providing a solid polymer electrolyte membrane; and
3 disposing said support in ionic communication with said solid polymer
4 electrolyte membrane.

1 15. The method of any of claims 1-14 wherein
2 said solid polymer electrolyte membrane has a first side and a second side
3 opposite said first side, and
4 said method further comprises disposing said support on each of said first side
5 and said second side to produce a membrane electrode assembly.

1 16. The method of any of claims 1-15 wherein said converting is thermally
2 converting.

1 17. The method of any of claims 1-5 wherein said one or more catalytic
2 components are metallic.

1 18. An electrode produced by a process comprising:
2 providing one or more vaporizable catalytic components;
3 converting said one or more vaporizable catalytic components into a vapor; and
4 depositing said vapor onto a support in an amount sufficient to produce a

5 concentration of said one or more catalytic components adapted to
6 produce a catalytically effective coating consisting essentially of said
7 one or more catalytic components on said support.

1 19. The electrode of claim 18 wherein said support is a carbon catalyst support
2 comprising a material selected from the group consisting of graphite, a carbon filament
3 bundle, reticulated carbon, carbon cloth, and carbon mesh.

1 20. The electrode of claim 19 wherein said carbon catalyst support
2 comprises a material selected from the group consisting of a carbon cloth and a coating
3 on a carbon cloth selected from the group consisting of carbon, a wet proofing
4 material, and a combination thereof.

1 21. The electrode of claims 18-20 wherein said support comprises a
2 membrane comprising a composite of polytetrafluoroethylene comprising impregnated
3 ion exchange media, said composite comprising a thickness of about 1 μm .

1 22. The electrode of any of claims 18-21 wherein said one or more vaporizable
2 catalytic components comprises one or more noble metals.

1 23. The electrode of claim 22 wherein said one or more vaporizable
2 catalytic components comprises one or more metals selected from the group consisting
3 of platinum, gold, silver, palladium, ruthenium, rhodium, iridium.

1 24. The electrode of any of claims 18-23 wherein said one or more
2 vaporizable catalytic components comprises platinum.

1 25. The electrode of any of claims 18-24 wherein said support comprises a
2 coating on a carbon cloth wherein said coating is selected from the group consisting of
3 carbon, a wet proofing material, and a combination thereof.

1 26. The electrode of claim 25 wherein said wet proofing material is
2 polytetra-fluoroethylene.

1 27. The method of any of claims 18-26 wherein said converting is thermally
2 converting.

1 28. The method of any of claims 18-21, 25, and 26 wherein said one or
2 more catalytic components are metallic.

1 29. An electrode comprising a support having disposed thereon a vapor
2 deposited electrocatalytic coating consisting essentially of one or more electrocatalysts,
3 wherein said one or more electrocatalysts are present in an amount of about 0.3
4 mg/cm² or less.

1 30. The electrode of claim 29 wherein said vapor deposited electrocatalytic
2 coating is deposited in a vacuum by electron-beam physical vapor deposition.

1 31. The electrode of claims 29 and 30 wherein, at a cell potential of about 0.6
2 V, an MEA containing said electrode half cell operating as a cathode yields about 800
3 mA cm⁻² or greater.

1 32. The electrode of claims 29-31 wherein said electrode comprises an
2 electrocatalytic active area of about 300 cm² or greater.

1 33. The electrode of claims 29-32 wherein said one or more catalytic
2 components comprises platinum.

1 34. The electrode of claims 29-33 wherein said support comprises a
2 membrane comprising a composite of polytetrafluoroethylene comprising impregnated
3 ion exchange media, said composite comprising a thickness of about 1 μm .

1 35 The electrode of claims 29-34 wherein said converting is thermally
2 converting.

1 36. An electrode comprising a support comprising a deposit disposed
2 thereon, said deposit comprising a catalytically effective load of an electrocatalyst
3 comprising an electrocatalytic active area at least in part comprising rod-shaped
4 structures.

1 37. The electrode of claim 36 wherein said rod-like structures are visible at
2 a magnification of at least about x10k.

1 38. The electrode of claims 36 and 37 wherein said deposit further
2 comprises particles of said electrocatalyst comprising an outer surface, wherein said
3 electrocatalytic active area comprises a majority of said outer surface of said particles.

1 39. The electrode of claims 36-38 wherein said support has a surface area, and
2 said deposit covers about 300 cm² or more of said surface area.

1 40. The electrode of claims 36-39 wherein said catalyst comprises platinum.

1 41. The electrode of claims 36-40 wherein, at a cell potential of about 0.6
2 V, an MEA containing said electrode as a half cell operating as a cathode yields a
3 power output of about 400 mA cm⁻² or greater.

1 42. The electrode of claims 36-40 wherein, at a cell potential of about 0.6
2 V, an MEA containing said electrode as a half cell operating as a cathode yields a
3 power output of about 800 mA cm⁻² or greater.

1 43 The electrode of claims 36-40 wherein, at a cell potential of about 0.6

2 V, an MEA containing said electrode as a half cell operating as a cathode yields a
3 power output of about 1000 mA cm⁻² or greater.

1 44. The electrode of claims 36-43 wherein said support comprises a
2 membrane comprising a composite of polytetrafluoroethylene comprising impregnated
3 ion exchange media, said composite comprising a thickness of about 1 μm.

1 45. A membrane electrode assembly comprising the support of any of claims
2 18-44.

1 46. The electrode of any of claims 18-44 wherein
2 said support has a surface area; and,
3 substantially all of said surface area ionically communicates with an ionomeric
4 membrane.

1 47. The electrode of claim 46 wherein said surface area is 300 cm² or
2 greater.

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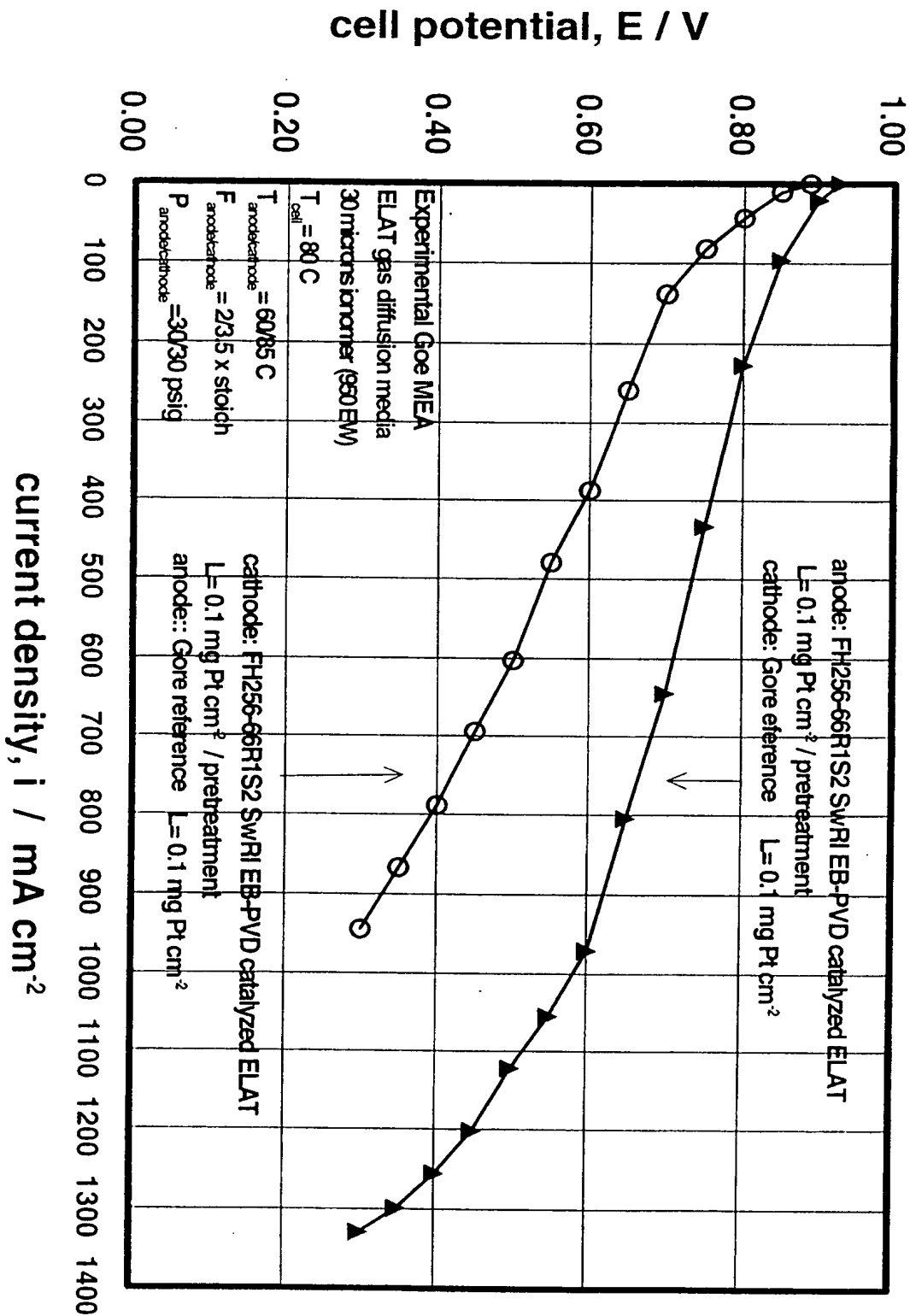


Figure 1

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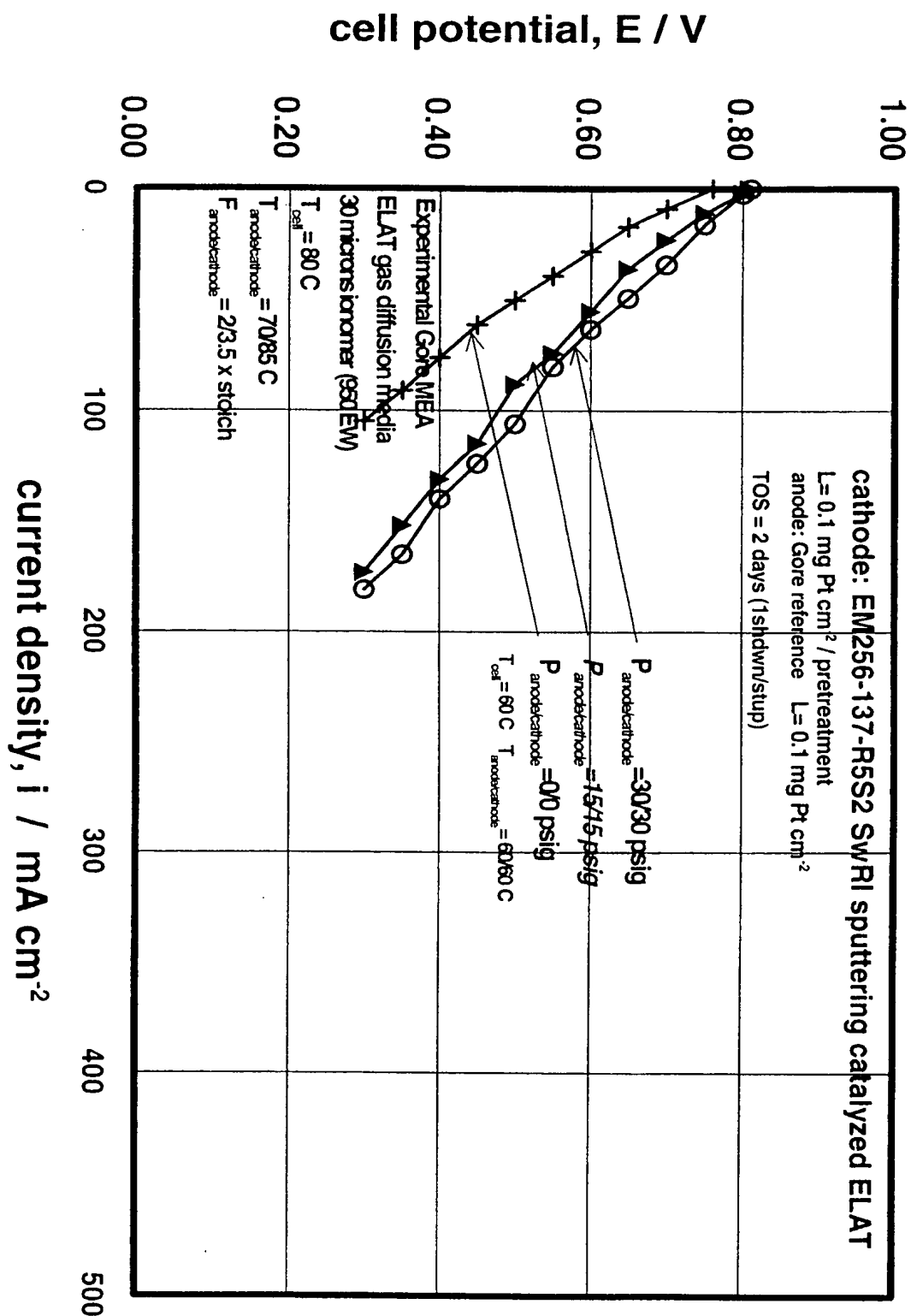


Figure 2

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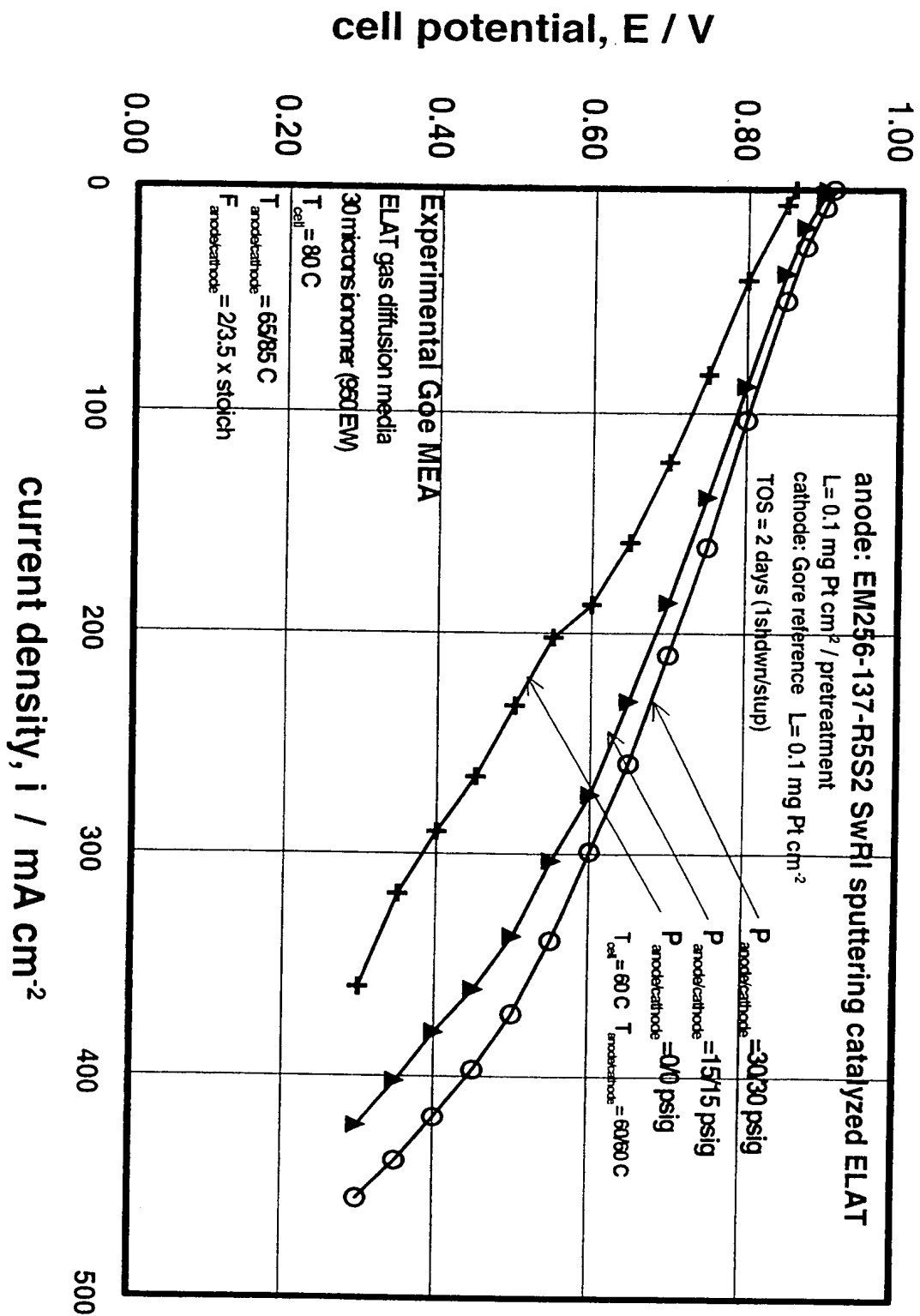


Figure 3

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cell & compensated potential, E / V

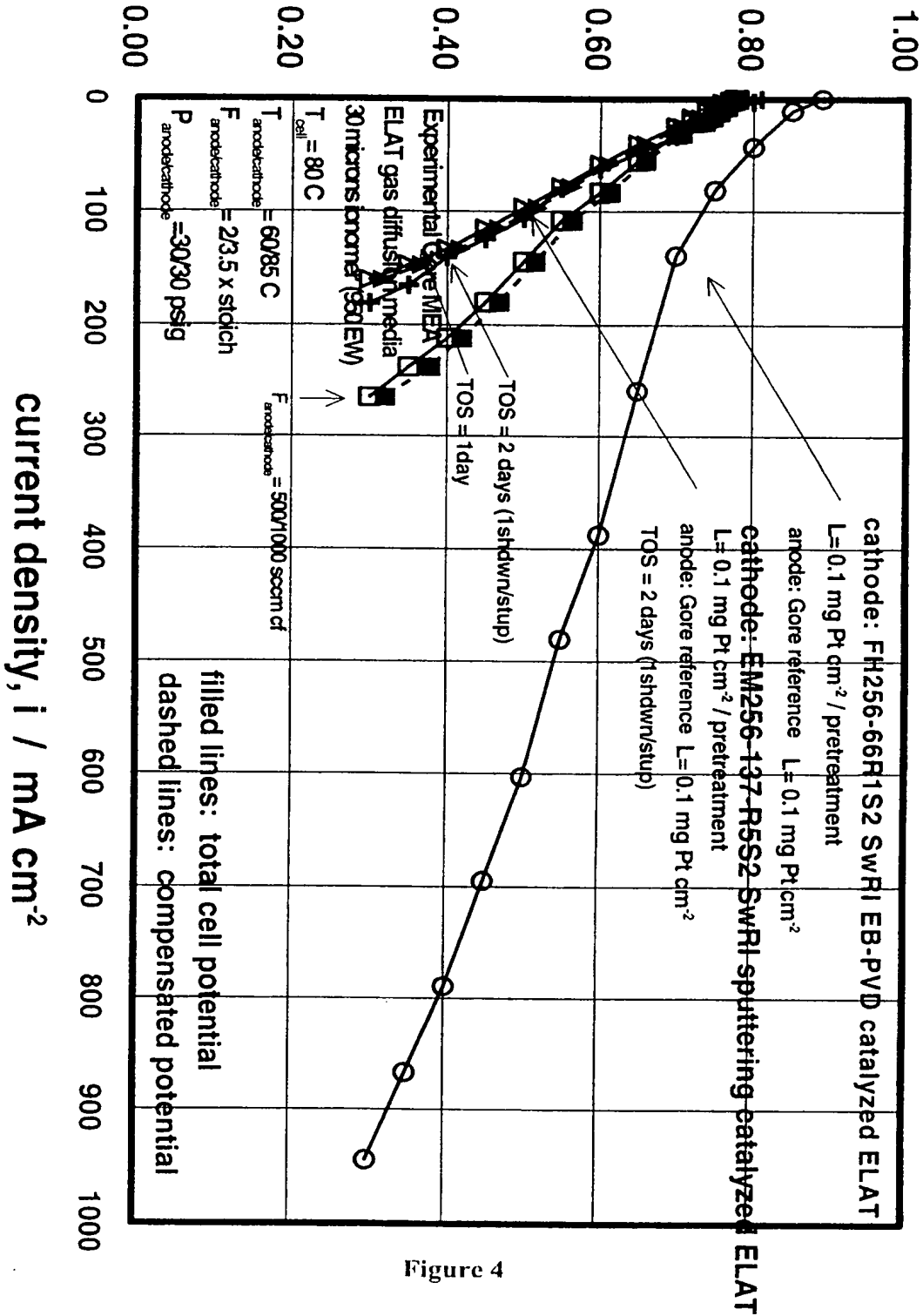


Figure 4

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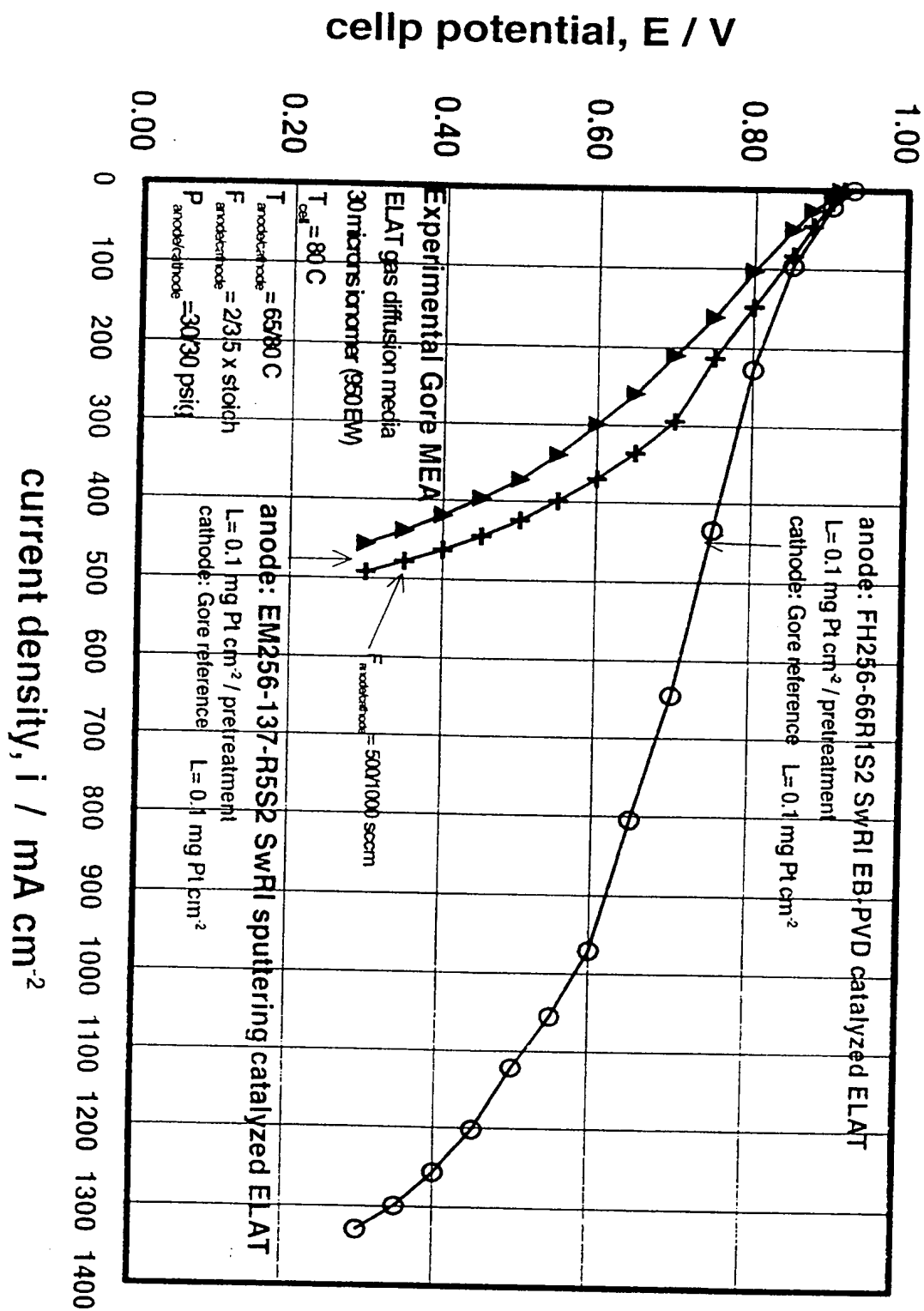


Figure 5

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cell & compensated potential, E / V

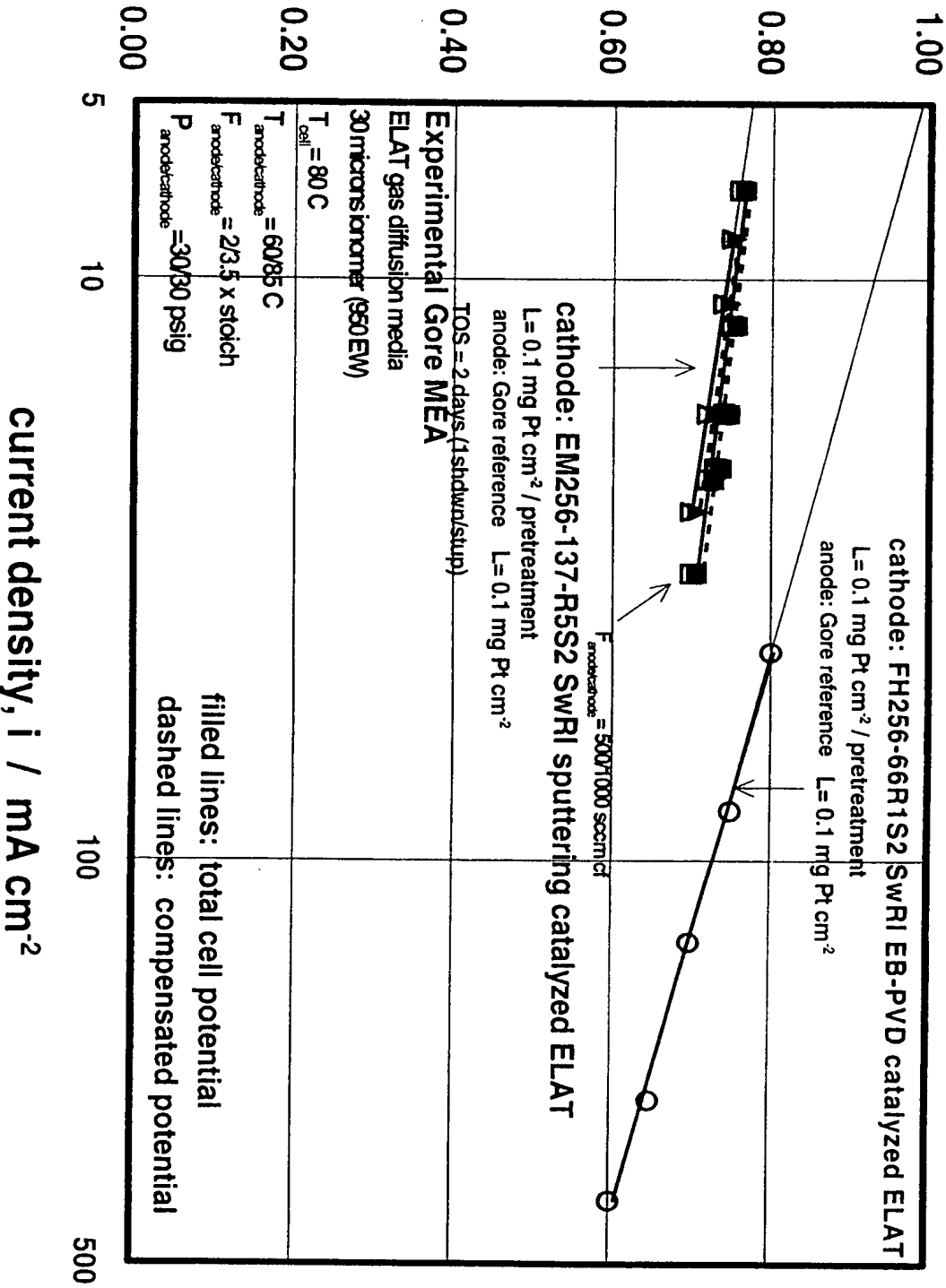


Figure 6



Figure 7

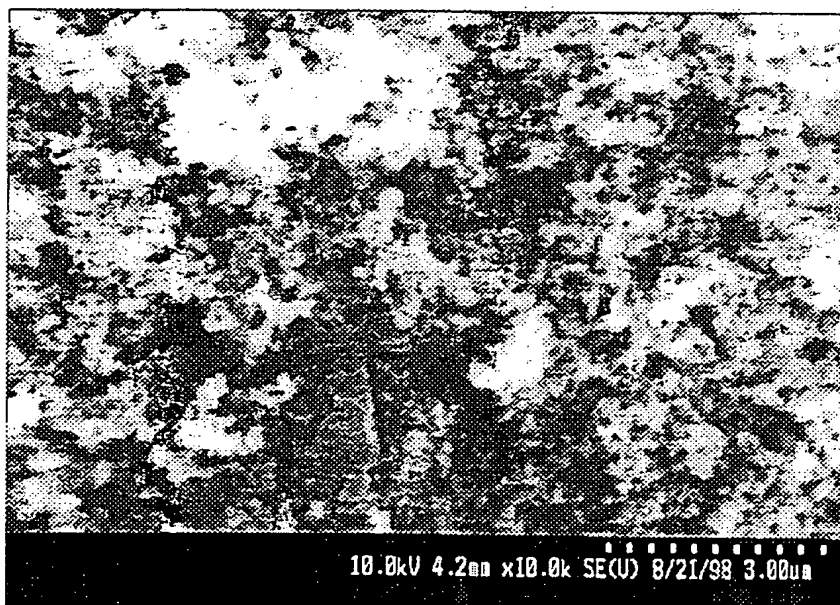


Figure 8



Figure 9

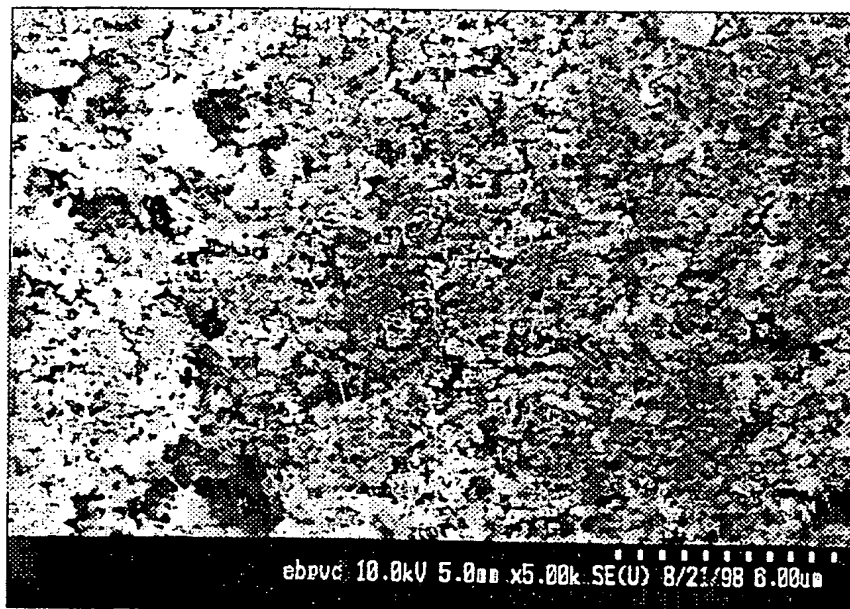


Figure 10

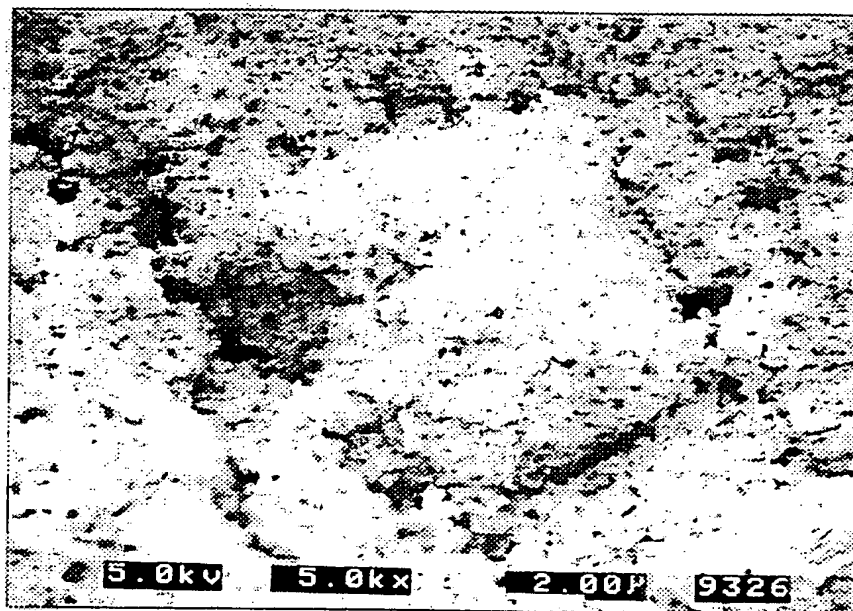


Figure 11

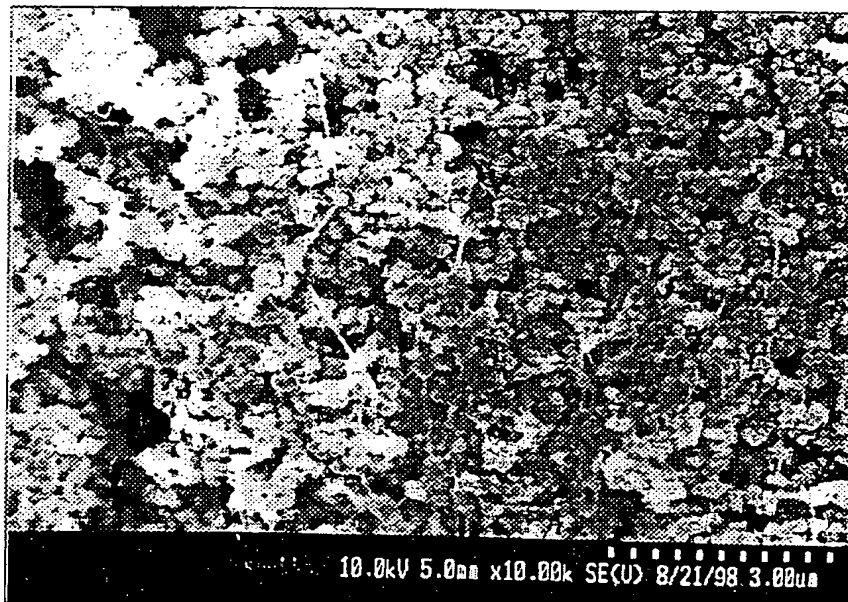


Figure 12

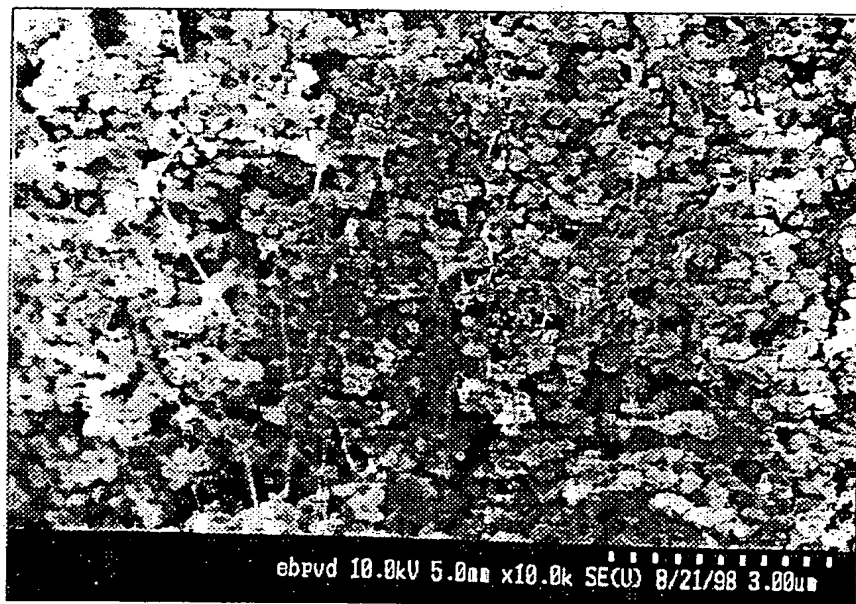


Figure 13

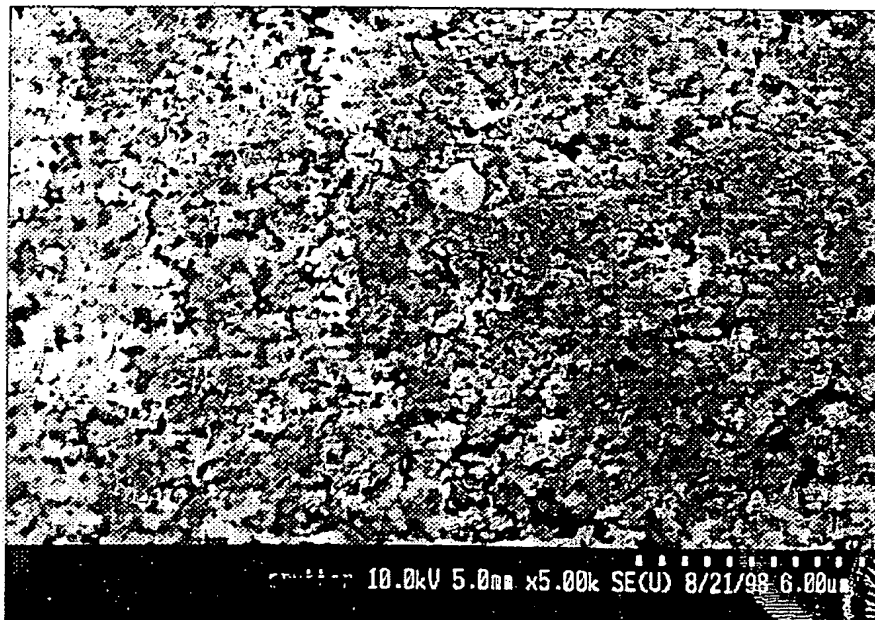


Figure 14



Figure 15

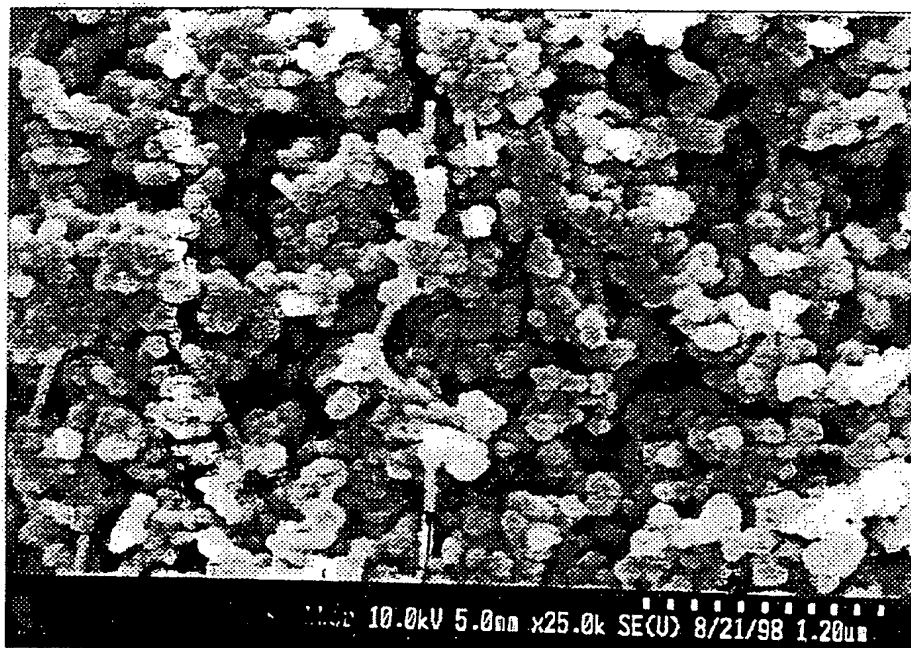


Figure 16

10

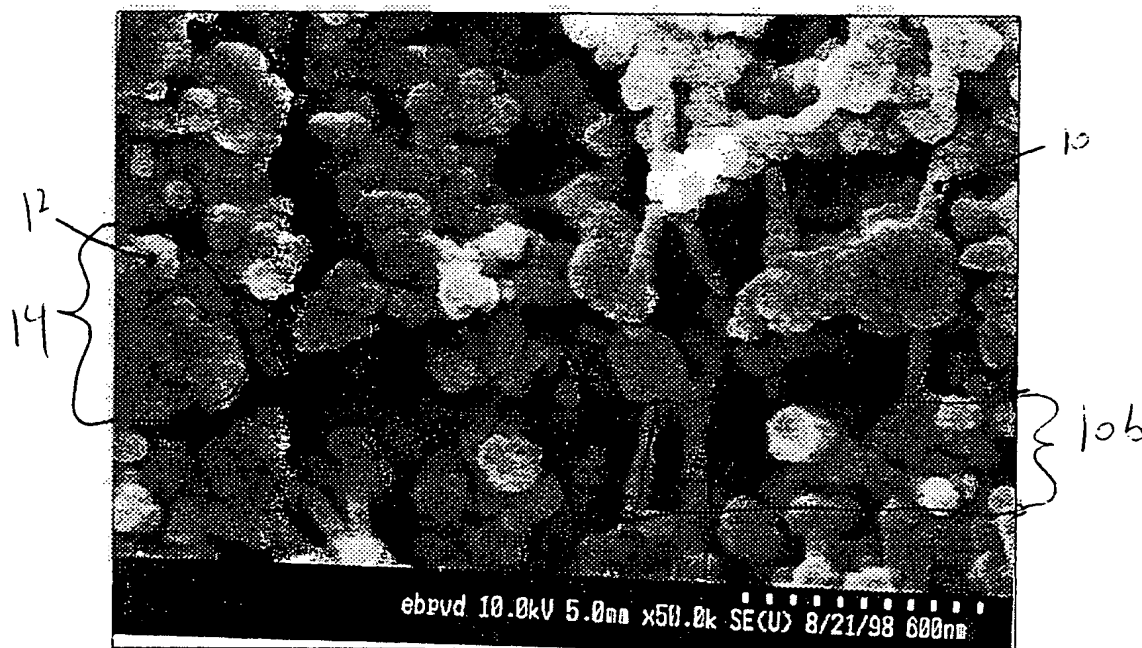


Figure 17

10a



Figure 18

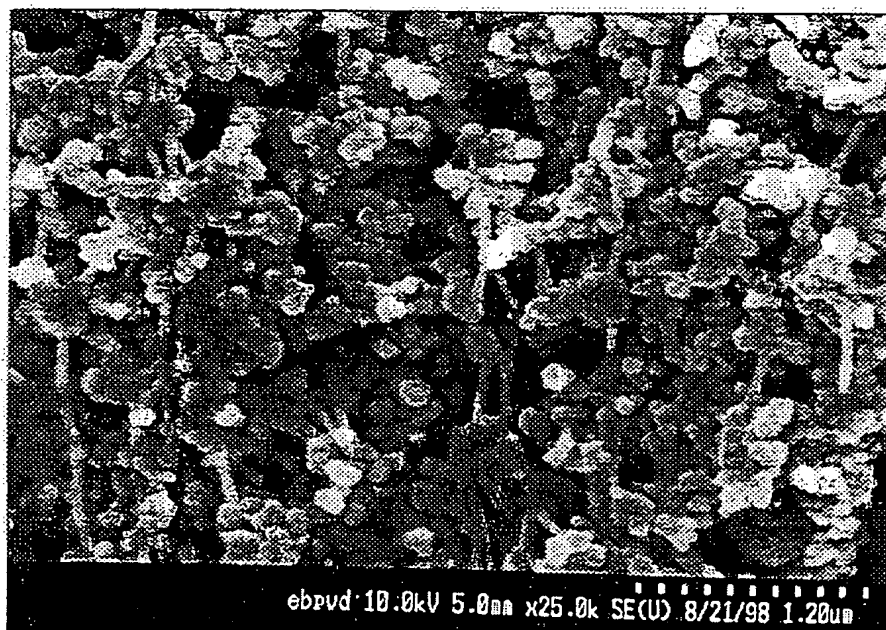


Figure 19

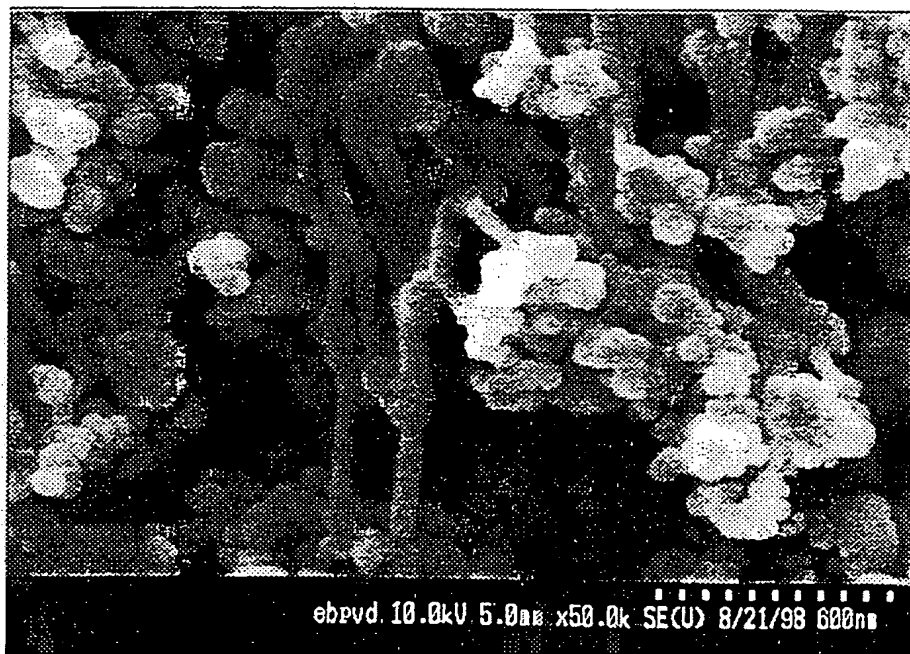


Figure 20



Figure 21

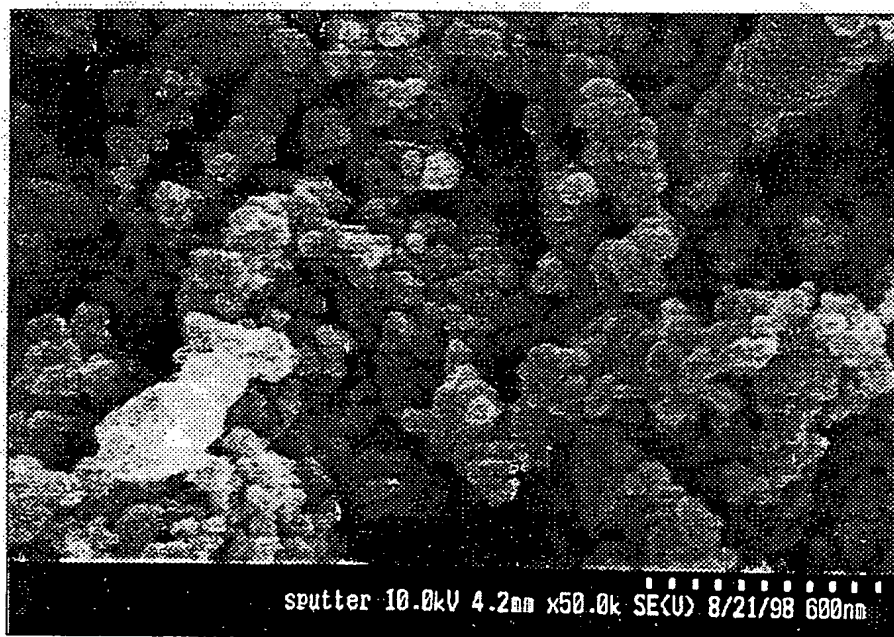


Figure 22

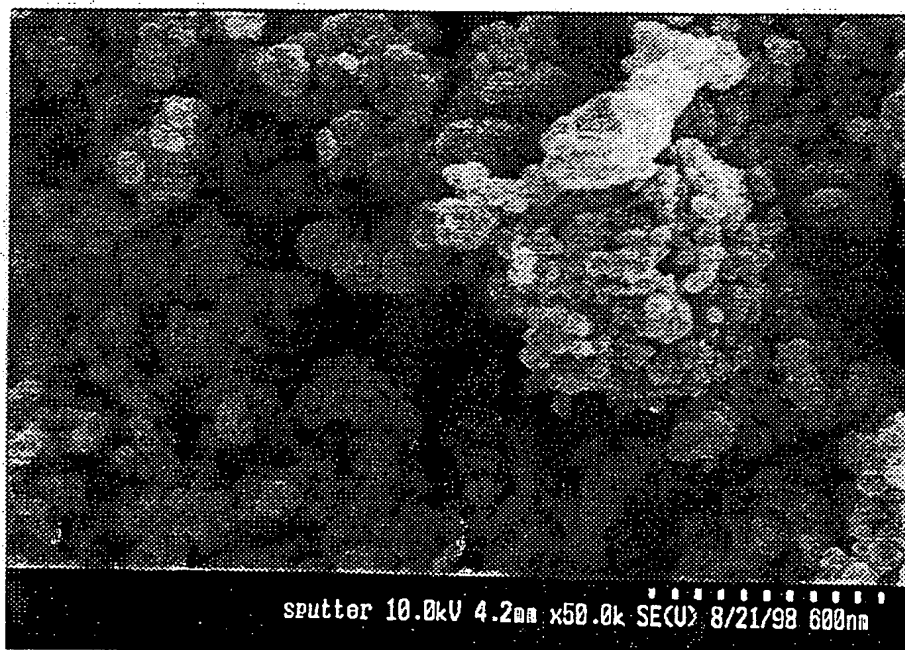


Figure 23

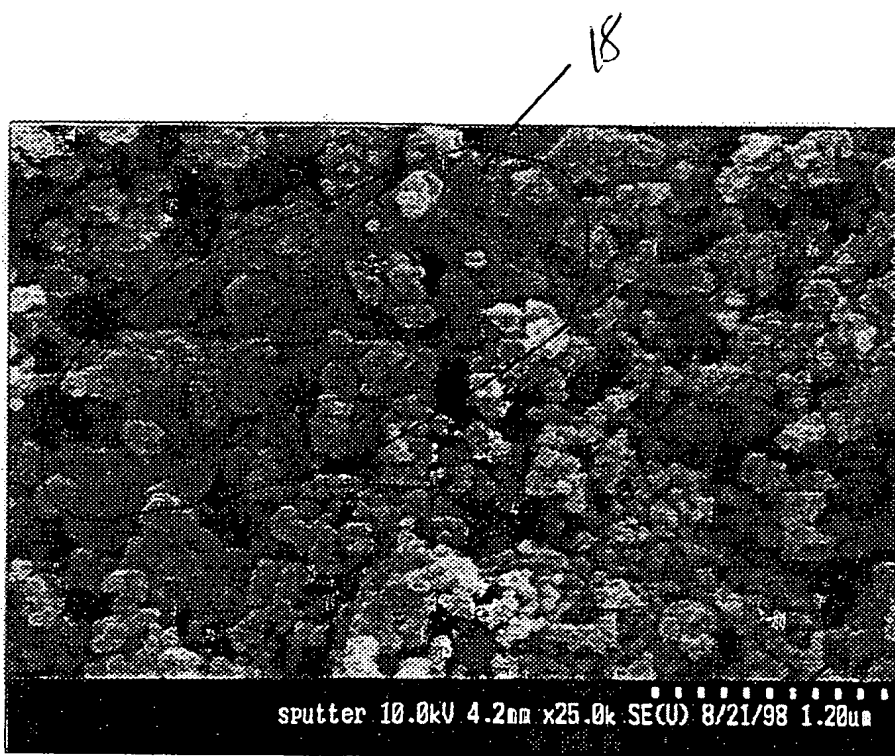


Figure 24

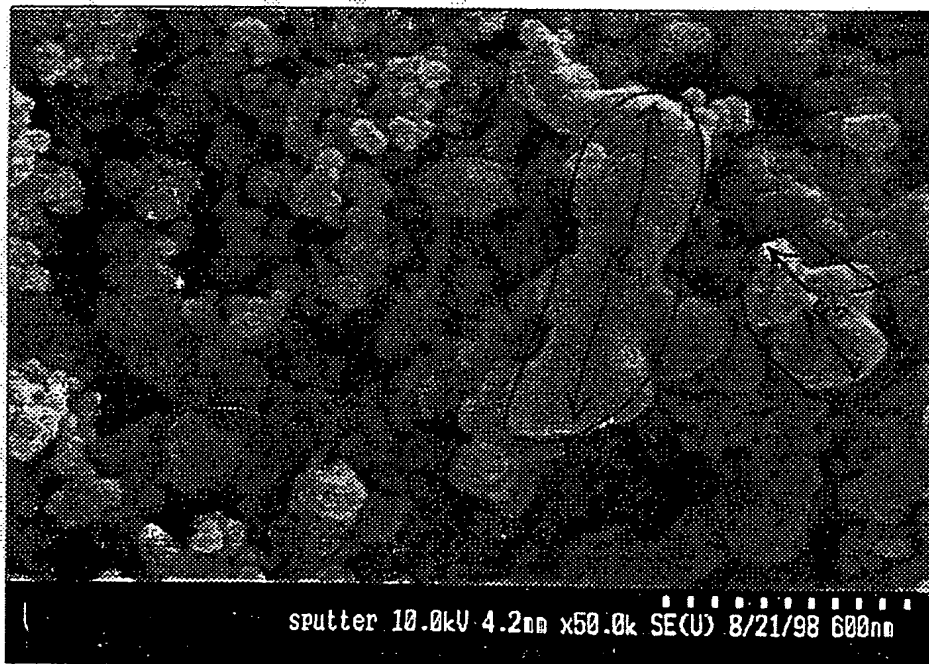


Figure 25

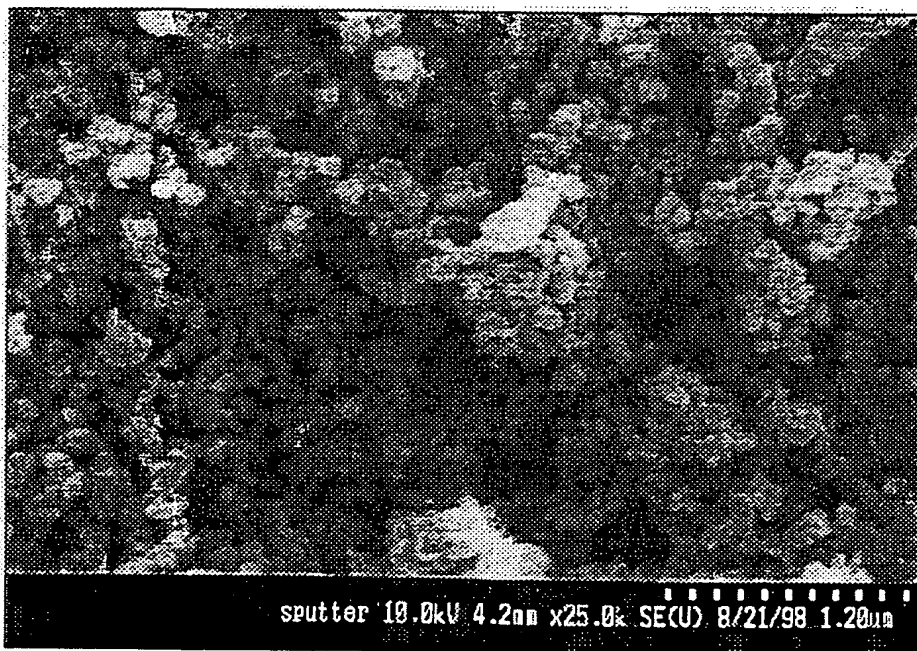


Figure 26

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/18938

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : C23C 16/26; H01M 8/10; B05D 5/12

US CL : 427/115,250,294; 204/294; 429/44

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 427/115,250, 252,229,294; 204/283,294,295,290R; 429/40,44

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
N/AElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
N/A

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 5,750,013 A (LIN) 12 May 1998, abstract and col. 2, Line 28 - col. 5, Line 55.	1-7,12-24 ----- 8-10,25-42
X -- Y	US 5,518,831 A (TOU ET AL.) 21 May 1996, col. 7, Line 55 - col. 10, Line 65.	1-30 ----- 31-42
A	US 4,460,660 A (KUJAS) 17 July 1984, entire document.	1-42

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
A document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
E earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*Z* document member of the same patent family
O document referring to an oral disclosure, use, exhibition or other means	
P document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 04 NOVEMBER 1998	Date of mailing of the international search report 27 NOV 1998
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer BRIAN TALBOT Telephone No. (703) 305-3775